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PAPERS

IN

MECHANICKS.

MECHANICKS.

In the Year 1796 the Society voted their GOLD MEDAL to Mr. ROBERT HYNAM, of St. Peterſburg, for his INSTRUMENT FOR GAUGING CUTTERS FOR WHEELS for the uſe of Clock and Watch-makers, on condition that he ſent a complete Inſtrument, and the Calculations he had made for it, to the Society for the uſe of the Public; and this Seſſion the Inſtrument and the Volume of Calculations having been received, the GOLD MEDAL was ſent to Mr. HYNAM. His Letters on the ſubject, with Plates of the Inſtrument, are here inſerted; and the Inſtrument itſelf, with a Volume of his Calculations, are reſerved in the Society's Collection.

MY LORD,

I TAKE the liberty of addreſſing myſelf to your Grace, in a matter (I preſume) of real utility to Clock and Watch-makers,

and

and indeed in all mechanical performances where wheels are uſed with teeth. It need not be diſſembled, that they do many things by rote and gueſs, which might be performed with more certainty and more expedition, by calling in the principles of arithmetic and geometry, not to ſay of mechanicks. Of this nature ſeems to be the uſing of cutters in gauging a given number of teeth in a wheel of a given diameter. Now the diameter of a circle being to its circumference nearly as 1 to 3 (which ratio may be accurate enough for the purpoſes here meant), a wheel of ſix inches diameter will have about eighteen inches in its circumference. Since then, in cutting a number of teeth in a wheel, you are to have as many interſtices or ſpaces between the teeth as the teeth themſelves, you will therefore have twice as many diviſions in the circumference as the number of teeth; viz. one half of the diviſions for the teeth themſelves, and the other half for the ſpaces between. You need then only to divide the circumference into twice the number of teeth, and you will have the breadth of each tooth, as well as the breadth of each ſpace between them, and this ſame breadth is the thickneſs of the cutter with which the teeth are to be cut. Suppoſe for example, in the wheel above-mentioned, of ſix inches diameter, you are to have 240 teeth, what will be the thickneſs of the cutter for cutting thoſe teeth? Twice 240 is 480; and $\frac{18}{480}$ inch gives $\frac{3}{80}$ of an inch for the breadth of each tooth as well as of each ſpace, and for the thickneſs of your cutter. This, notwithſtanding, I have found by repeated operations, that $\frac{3}{90}$ or $\frac{1}{30}$ will anſwer better than $\frac{3}{80}$. For that, beſides its coming out in rounder numbers, ſeems to be founded in the very nature of things, ſince the teeth grow narrower towards the centre, than they are towards the circumference; and ſuch an allowance is always indiſpenſably to be made in wheels of ſmall diameters, wherein the length of the teeth is very conſiderable in reſpect of the length of the diameters. Taking therefore this $\frac{1}{30}$ along with us, and ſuppoſing farther every inch to be divided into forty parts, if the diameter of a wheel be 6 inches, or 240 of ſuch diviſions, and the number of its teeth 240, we ſhall have for the breadth of a tooth or ſpace, and for the thickneſs of a cutter to cut it with, $\frac{3}{2}$ or $1\frac{1}{2}$ of thoſe fortieth parts of an inch, or $\frac{1}{30}$ of an inch as before. After the ſame manner the thickneſs of a cutter for a wheel of any diameter, and any number of teeth, may be calculated: for inſtance, if the diameter of a wheel be 38 of thoſe fortieth parts, and the number of teeth 66, the thickneſs of the cutter will be $\frac{3}{2}$, $\frac{38}{66}$, or $\frac{38}{66} \times \frac{3}{2}$ of thoſe fortieth parts of an inch; or again, $\frac{38}{66} \times \frac{1}{30}$ of an inch. But alſo the thickneſs of a cutter may be immediately deduced from the firſt cutter, viz. from that which ſerved for a wheel of ſix inches diameter, with 240 teeth in it; for the breadths of the teeth, as well as the thickneſſes of the cutters, are *directly* as the circumferences or diameters of the wheels, and *inverſely* as the numbers of the teeth. You need only therefore multiply $\frac{1}{30}$ of an inch by the diameter of a wheel, and divide the product by the number of teeth. Thus, in the wheel immediately preceding, the thickneſs of the cutter is $\frac{1}{30} \times \frac{38}{66}$.

In order to exhibit the thickneſs of a cutter accurately, for all ſorts of wheels uſed in watch and clock-making, I have calculated tables, and invented a gauging inſtrument. The inſtrument is a ſector of a circle, on the arch ofwhich there are laid down ſix inches, each divided into forty equal parts;[*] and it has two indexes, one from the centre of motion to the circumference, the other from the ſame centre to a moveable piece of ſteel which reaches to the gauge.

Theſe indexes are to one another as $11\frac{1}{4}$ inches to $\frac{1}{2}$ an inch, or as 45 to 2, and

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[*] Since then the ſix inches are expanded here on an arch, inſtead of being laid down in a ſtrait line, they occupy leſs ſpace, which furniſhes us with an additional reaſon why $\frac{1}{30}$ or $\frac{3}{90}$ of an inch ſhould be taken rather than $\frac{3}{80}$.

therefore, as $\frac{3}{4}$ to $\frac{1}{30}$. So that, whilſt the ſhorter index moves $\frac{1}{30}$ of an inch, the longer will in the ſame time move $\frac{3}{4}$ or $\frac{30}{40}$ of an inch, *i. e.* 30 of thoſe diviſions, 40 of which every inch on the arch is divided into. And, converſely, whilſt the longer index moves $\frac{30}{40}$ of an inch, the ſhorter will move $\frac{1}{30}$ of the ſame; and will therefore exhibit in the gauge $\frac{1}{30}$ of an inch for the thickneſs of a cutter to cut 240 teeth, in a wheel of ſix inches diameter. And the ſame holds good for a cutter of any other thickneſs.

Now the tables calculated by me are accommodated to the longer index of this gauging inſtrument; ſince, whatever thickneſs of a cutter is ſhewn from the tables by the longer index, the true thickneſs of it is $\frac{2}{45}$ of the former, and is ſhewn on the gauge by the ſhorter index. For this reaſon, in the wheel before-mentioned (of 6 inches or 240 diviſions in the diameter, with 240 teeth in it), I aſſume the thickneſs of the cutter, not $\frac{1}{30}$ of an inch, but

30

30 of thoſe fortieth diviſions; and from that wheel, as a ſtandard, I deduce all other wheels, *e. g.* a wheel of 38 diviſions in diameter with 66 teeth in it; wherein the number of diviſions in the diameter of the wheel, *viz.* 38, I multiply by the *conſtant number* 30, and divide the product by the number of teeth in the wheel, viz. by 66; and the quotient $30\times\frac{38}{66}=17.273$ is the thickneſs of the cutter required, as ſhewn on the arch of the ſector by the long index. And this is the rule by which the tables have been calculated, and which is manifeſt from what has been ſaid above.

I ſhall only add a few words concerning the uſe of the tables and the inſtrument. A wheel of any diameter, with any number of teeth being given, I look in the tables for the thickneſs of the cutter proper for that wheel. Having found it, I bring the longer index of the inſtrument to that number; and at the ſame time the gauge (by means of the ſhorter index) exhibits to me the true thickneſs of that cutter between the two pieces of ſteel.

Thus much, my Lord, I lay before your Grace, as Preſident of a Society which has ſo well deſerved of the Arts and of Great Britain. If I meet your and their approbation, which is all the encouragement I aim at, I may lay before your Grace many other inſtruments and machines, with their deſcription and uſes, which, at the ſame time that they greatly ſhorten and ſimplify the buſineſs of watch and clock-making, render the execution of their ſeveral parts more accurate.

I have the honour to ſubſcribe myſelf,

My Lord,

Your Grace's

Moſt obedient

and moſt humble ſervant,

Robert Hynam.

St. Peterſburg,
Sept. 2d, 1795.

His Grace the Duke of Norfolk.

The number of calculations in this work (beginning with $\frac{1}{8}$ of an inch diameter, increaſing $\frac{1}{40}$ of an inch, and ending with ſix inches diameter) conſiſt of twenty-three thouſand five hundred and upwards. In the courſe of the work ſeveral numbers have no decimals affixed to them. This is when the diviſor is not quite contained in the dividend, and the quotient is only approximate. Thus, ſuppoſe a quotient ſhould be 31.99765, as I put but two places of decimals in the tables, I write 32.00, or if any quotient ſhould be 33.5294, making an allowance for the figure 9. In the third place, I write 33.53, and my error in this caſe is but 0.0005, *i. e.* but $\frac{1}{2}$ of a thouſandth part of unity.

Annexed is a Table of Proportions.

I have begun with the leaſt Diameter, introduced two intermediate ones, and the greateſt Diameter.

TABLE OF PROPORTIONS.

No. of Teeth	Thickneſs of Cutter.	No. of Teeth	Thickneſs of Cutter.	No. of Teeth	Thickneſs of Cutter.	No. of Teeth	Thickneſs of Cutter.
5 *Diviſions*		40 *Diviſions*				67	17.91
10	15	30	40	48	25	68	17.65
11	13.64	31	38.71	49	24.49	69	17.39
12	12. 5	32	37. 5	50	24.	70	17.14
13	11.54	33	36.36	51	23.53	71	16.90
14	10.71	34	35.29	52	23.08	72	16.67
15	10.	35	34.29	53	22.64	73	16.44
16	9.38	36	33.33	54	22.22	74	16.22
17	8.32	37	32.43	55	21.82	75	16.
18	8.33	38	31.58	56	21.43	76	15.79
19	7.89	39	30.77	57	21.05	77	15.58
20	7. 5	40	30.	58	20.69	78	15.38
21	7.14	41	29.27	59	20.34	79	15.19
22	6.82	42	28.57	60	20.	80	15.
23	6.52	43	27.91	61	19.67	81	14.81
24	6.25	44	27.27	62	19.35	82	14.63
25	6.	45	26.67	63	19.05	83	14.46
26	5.77	46	26.09	64	18.75	84	14.29
		47	25.53	65	18.46	85	14.12
				66	18.18	86	13.95

No. of Teeth	Thickneſs of Cutter.	No. of Teeth	Thickneſs of Cutter.	No. of Teeth	Thickneſs of Cutter.	No. of Teeth	Thickneſs of Cutter.
87	13.79	72	46.67	110	30.55	79	91.14
88	13.64	73	46.03	111	30.27	80	90.
89	13.48	74	45.41	112	30.	81	88.89
90	13.33	75	44. 8	113	29.73	82	87.81
91	13.19	76	44.21	114	29.47	83	86.75
92	13.04	77	43.64	115	29 22	84	85.71
93	12.90	78	43.08	116	28.97	85	84.71
94	12.77	79	42.53	117	28.72	86	83.72
95	12.63	80	42.	118	28.47	87	82.76
96	12. 5	81	41.48	119	28.24	88	81.82
97	12.37	82	40.98	120	28.	89	80.90
98	12.24	83	40.48	121	27.77	90	80.
99	12.12	84	40	122	27.54	91	79.12
100	12.	85	39.53	123	27.32	92	78.26
		86	39.07	124	27.10	93	77.42
112	*Diviſions*	87	38.62	125	26.88	94	76.60
50	67. 2	88	38.18	126	26.67	95	75.79
51	65.88	89	37.73	127	26.46	96	75.
52	64.62	90	37.33	128	26.25	97	74.23
53	63.40	91	36.92	129	26.05	98	73.47
54	62.22	92	36.52	130	25.85	99	72.73
55	61.09	93	36.13	131	25.65	100	72
56	60.	94	35.74	132	25.45	101	71.29
57	58.95	95	35.37	133	25.26	102	70.59
58	57.93	96	35.	134	25.07	103	69.90
59	56.95	97	34.64	135	24.89	104	69.23
60	56.	98	34.29	136	24.71	105	68.57
61	55.08	99	33.94	137	24.53	106	67.92
62	54.19	100	33. 6	138	24.35	07	67.29
63	53.33	101	33.27	139	24.17	108	66.67
64	52. 5	102	32.94	140	24.	109	66.06
65	51.69	103	33.62			10	65.45
66	50.91	104	32.31	240	*Diviſions*	11	64.86
67	50.15	105	32.	74	97.30	12	64.29
68	49.41	106	31.70	75	96.	113	63.72
69	48.70	107	31.40	76	94.74	114	63.16
70	48.	108	31.11	77	93.51	115	62.61
71	47.32	109	30.83	78	92.31	116	62.07

No. of Teeth	Thickneſs of Cutter.	No. of Teeth	Thickneſs of Cutter.	No. of Teeth	Thickneſs of Cutter.	No. of Teeth	Thickneſs of Cutter.
117	61.54	156	46.15	195	36.92	234	30.77
118	61.02	157	45.86	196	36.73	235	30.64
119	60.50	158	45.57	197	36.55	236	30.51
120	60.	159	45.28	198	36.36	237	30.38
121	59.50	160	45.	199	36.18	238	30.25
122	59.02	161	44.72	200	36.	239	30.13
123	58.54	162	44.44	201	35.82	240	30.
124	58.06	163	44.17	202	35.64		
125	57. 6	164	43.90	203	35.47		
126	57.14	165	43.64	204	35.29		
127	56.69	166	43.37	205	35.12		
128	56.25	167	43.11	206	34.95		
129	55.81	168	42.86	207	34.78		
130	55.38	169	42.60	208	34.62		
131	54.96	170	42.35	209	34.45		
132	54.55	171	42.11	210	34.29		
133	54.14	172	41.86	211	34.12		
134	53.73	173	41.62	212	33.96		
135	53.33	174	41.38	213	33.80		
136	52.94	175	41.14	214	33.64		
137	52.55	176	40.91	215	33.49		
138	52.17	177	40.68	216	33.33		
139	51.80	178	40.45	217	33.18		
140	51.43	179	40.22	218	33.03		
141	51.06	180	40.	219	32.88		
142	50.70	181	39.78	220	32.73		
143	50.35	182	39.56	221	32.58		
144	50.	183	39.34	222	32.43		
145	49.66	184	39.13	223	32.29		
146	49.32	185	38.92	224	32.14		
147	48.98	186	38.71	225	32.		
148	48.65	187	38.50	226	31.86		
149	48.32	188	38.30	227	31.72		
150	48.	189	38.10	228	31.58		
151	47.68	190	37.89	229	31.44		
152	47.37	191	37.70	230	31.30		
153	47.06	192	37. 5	231	31.17		
154	46.75	193	37.31	232	31.03		
155	46.45	194	37.11	233	30.90		

SIR,

STIMULATED by the mark of honour conferred upon me by the Society, I reviewed the work I had preſented to them, and happily fell on a method of calculating the tables with more eaſe, much ſhorter, and leſs liable to error. This encourages me (if it meets the Society's approbation) to make the gauging inſtrument more univerſal, without altering its conſtruction in the ſmalleſt degree. I mean only to extend the arch upon the inſtrument ſix inches more than it is at preſent, and to divide one of its edges into 12 inches, and each into 40 equal parts*. By this ſmall addition, the thickneſs of cutters for cutting wheels may be accurately determined from $\frac{1}{8}$ of an inch to two feet diameter, in which may be cut from 8 teeth to 2000 and upwards; a number, I believe, never uſed in practice. The inſtrument not admitting a ſcale to be laid down more than 12 inches in length, therefore, when a diameter exceeds that length, the radius taken and doubled gives the diameter.

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* A ſcale, laid down on an arch of a circle whoſe radius is only 11¼ inches, ſhould not be uſed in gauging wheels of large diameters. Such wheels ſhould have their diameters gauged by a ſtrait line divided into inches, and each inch into forty equal parts: for in large wheels the length of the teeth bear a ſmall proportion to the diameters; but in wheels of ſmall diameters the length of the teeth is very conſiderable in reſpect to the length of the diameters, as I have before obſerved.

As the following rule is very ſimple and eaſily underſtood, I think it renders the continuation of the tables unneceſſary. A few examples may ſuffice, more eſpecially as the number of wheels uſed of a larger diameter than ſix inches bears a ſmall proportion to thoſe wheels uſed of a leſs diameter.

RULE.

Divide the conſtant number 30 by the number of teeth in the wheel, and multiply the quotient by the number of diviſions contained in its diameter, and the product will be the thickneſs of the cutter. And by adding the thickneſs of the cutter found to the quotient, you have the thickneſs of another cutter for a wheel which contains one diviſion more in diameter; for, as long as the number of teeth in the wheel continues the ſame, whatever are the number of diviſions in the diameter of the wheel, there is only one calculation to be made; all the other thickneſſes are found by *addition only*.

EXPLANATION.

Suppoſe the number of teeth in the wheel is 240, and the diviſions in the diameter 241. Divide 30, the conſtant number, by 240, and the quotient will be 125. Multiply this quotient 125 by 241, the diviſions in the diameter of the wheel, and the product will be 30.125, the thickneſs of the cutter in this caſe. Now, if the diviſions in the diameter of the wheel are 242, and the number of teeth in the wheel 240, add 125 the quotient, and 30.125 the thickneſs of the cutter juſt found, and the ſum of 30.250 will be the thickneſs of a cutter for a wheel having 242 diviſions in diameter, and 240 teeth. Again, if the diviſions in the diameter of the wheel are 243, and the number of teeth in the wheel 240, add 125 and 30.250, and the ſum 30.375 will be the thickneſs of a cutter for 243 diviſions in diameter, as may be farther ſeen by the following ſtatement, and may be compared by the tables ſent.

Diviſion in Diam. ,83333 Quotient
Teeth $\frac{30}{36}$=,83333,83333 ×60=49,99980 *Thickneſs of cutter.*
61=50,83313
62=51,66646
63=52,49979
64=53,33312
65=54,16645
66=54,99978
67=55,83311
68=56,66644

Place the quotient over the thickneſs of the cutter 49.99980; add them together for another thickneſs of cutter for a wheel having one more diviſion in diameter, viz. 61, and ſo proceed with 62, 63, 64, &c. &c. The teeth in the wheel to remain the ſame number 36. But to avoid intermediate numbers, the teeth in the wheel remaining the ſame, and the diameter of the wheel increaſing to any number of diviſions, you have only to multiply the quotient found by the number of diviſions in the new diameter, and you will have the thickneſs of the cutter. If the diameter of the wheel ſhould be leſs, proceed as above.

Examples wherein the Teeth and Diameters differ.

	W.D. Thickneſs Cutter.	W.D. Thickneſs Cutter.
Teeth	$\frac{30}{250} \times 295 = 35,40$	$\frac{30}{425} \times 566 = 39,95$
	$\frac{30}{275} \times 292 = 31,85$	$\frac{30}{600} \times 720 = 36$
	$\frac{30}{300} \times 250 = 25$	$\frac{30}{1000} \times 480 = 14,40$
	$\frac{30}{336} \times 298 = 35,52$	$\frac{30}{1000} \times 960 = 28,80$
	$\frac{30}{380} \times 560 = 44,25$	$\frac{30}{2000} \times 960 = 14,40$

The foregoing numbers $\frac{3\bullet}{36}$ ſhould have but two places of decimals agreeably to the tables: then they would be,

Thickneſs of Cutter.
50,
50,83
51,67
52,5
53,33
54,17
55,
55,83
56,67

I am, Sir,

Your moſt obedient humble ſervant,

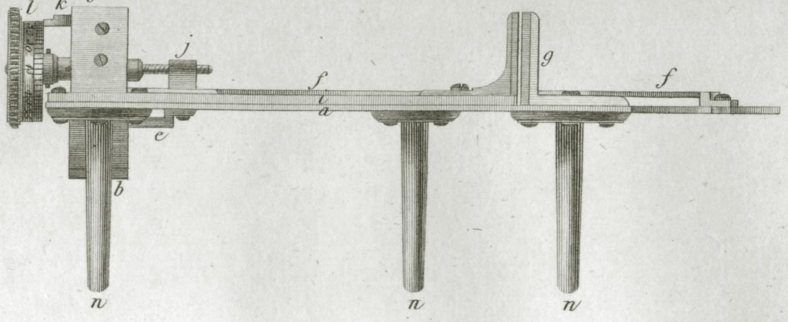
Robert Hynam.

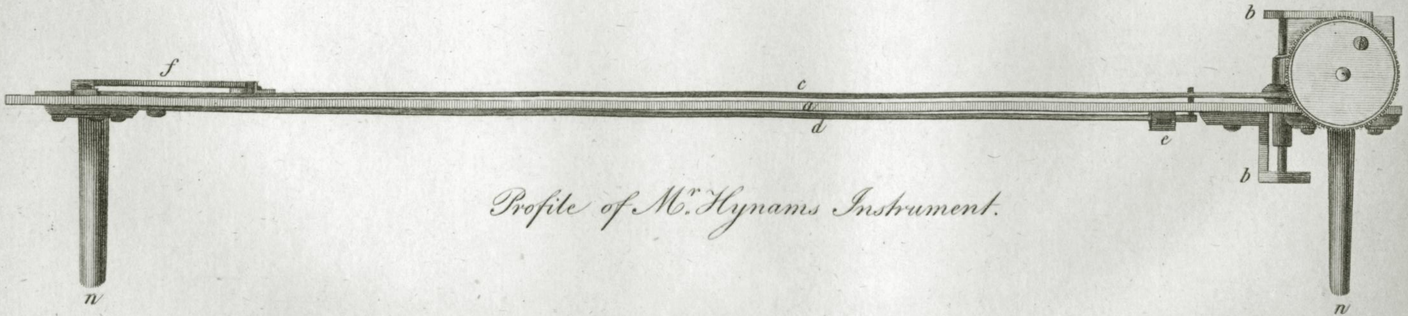
St. Peterſburgh, Jan. 20, 1797.

Mr. More.

Deſcription

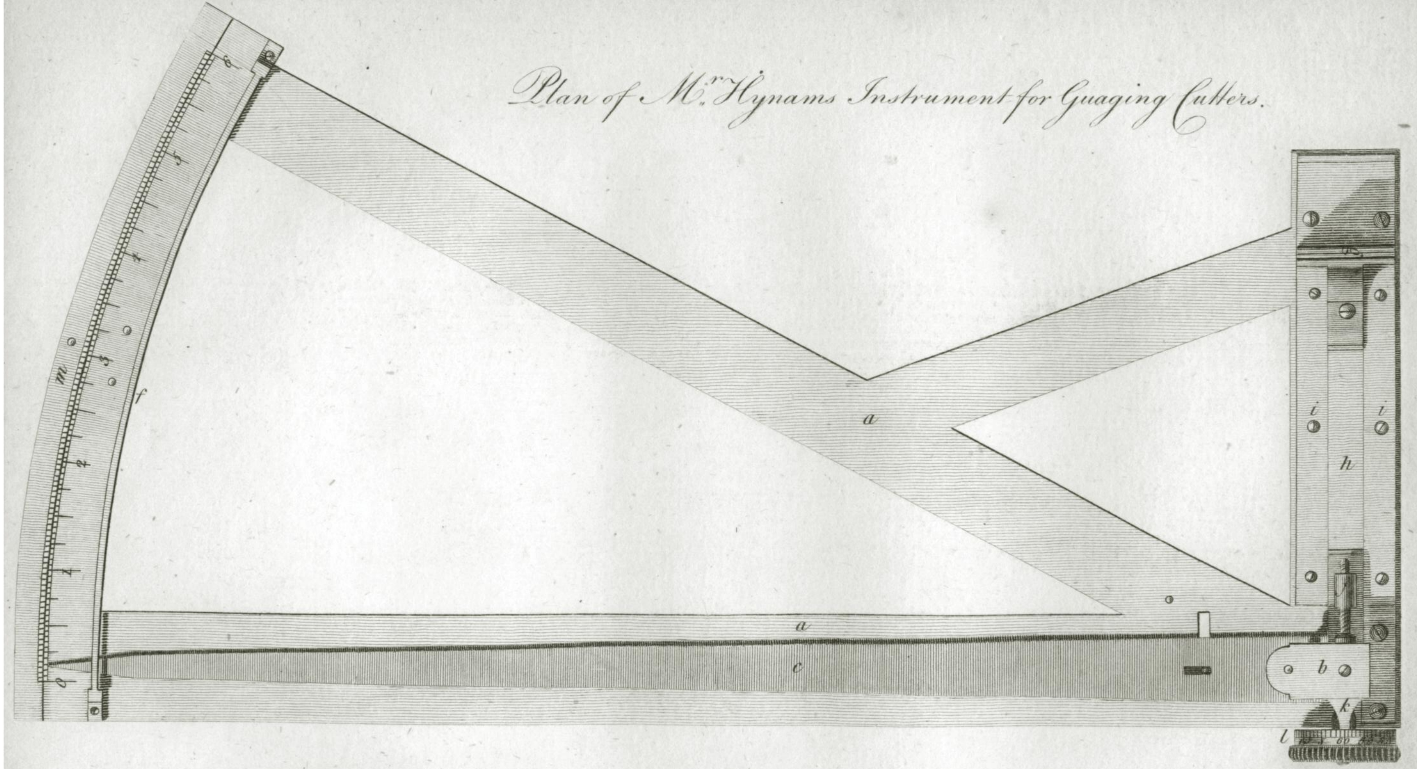
End View of Mr. Hynams Instrument.





Profile of Mr. Hynams Instrument.

Plan of Mr. Hynams Instrument for Guaging Cutters.



Deſcription of Mr. HYNAM'*s Inſtrument for* GAUGING CUTTERS. *Plate I.*

a. The baſe on which all the work is fixed.

b. One of the cocks, there being two, which the index moves in, but the under one cannot be ſeen in the plate of the Plan.

c. The index, having under it a ſpring *d*. as ſhewn in Plate II.

f. A bridge over the point of the index.

g. A fixed cock to the baſe, with ſteel chop.

h. A dovetail: on one end is fixed a cock having a ſteel chop, which forms the gauge with *g*.

i. The ſides in which the dovetail moves.

j. A ſteel ſtud, tapped and fixed to the dovetail.

k. A cock fixed to the inſide of the cock *b*. through which paſſes the adjuſting ſcrew to the ſteel ſtud *j*.

l. The divided nut upon the adjuſting ſcrew.

m. A ſegment of a circle, divided into ſix parts in the Plan, each part containing forty diviſions, and being, on the Inſtrument at large, twelve inches in length.

The letters of reference to the ſeveral parts are the ſame in Plate II. as in Plate I. excepting that in Plate II. the two cocks marked *b.* and the bridge of the ſpring *d.* are ſhewn, which cannot be ſeen in Plate I.

n. The feet of the inſtrument.

A Bounty of SIXTY-FIVE POUNDS was this Seſſion voted to Mr. SIMON GOODRICH, for the application of a CRANK to anſwer the purpoſes of an Eſcapement in Clocks; of which a Deſcription and Print are hereunto annexed, and the Clock itſelf reſerved in the Society's Repoſitory, for the inſpection of the Public.

SIR,

I BEG leave to preſent to the Society for the Encouragement of Arts, Manufactures, and Commerce, for their inſpection, a Clock with the ſimple application of a Crank, as an eſcapement, to give motion to the pendulum.

The Clock does not appear in ſo ſimple a ſtate as it might, had the train been made on purpoſe for the invention, with all the wheels, and fewer of them in number, placed between the two plates, with the crank only behind the back plate: but I was induced to apply the motion to a ready-made clock, in order to try, by the ſame machine, a point of which I had ſome doubts; namely, that perhaps, on account of the greater velocity of the acting part, this method might require more power than the common. The experiment proved in favour of the crank; though, with the common eſcapement well adjuſted, I kept the pendulum in motion for ſome days, with as ſmall a power as I could with the crank; yet the ſame ſmall power with the common eſcapement was not ſufficient to maintain the motion ſo long as it was with this crank. The weight here uſed for this eight-day piece, which has kept it going for about ſix months without once failing, is 4 $\frac{1}{2}$ lb. It has in it an allowance of more than half for the loſs of power from foulneſs or other accidents; for 2 lb. was ſufficient to work the clock for ſeveral weeks, when firſt put together.

That I may be enabled to refer to ſome particulars in this letter, I have incloſed a ſketch and deſcription of this invention. See the Plate.

The advantages of this Eſcapement are, firſt, ſimplicity of conſtruction, conſequently cheapneſs. It can eaſily be adopted by the manufacturers of the common wooden Dutch clocks, as the whole eſcapement can be formed of a few pieces of wire bent till properly adjuſted, without even the neceſſity of the adjuſting ſcrews I I. Therefore the benefits of this invention may extend even to the poorer part of the public.

2dly, Total ſilence when going; clocks being excluded by many perſons, to whom and from many places where uſeful, upon account of their noiſe.

3dly, Keeping good time, ariſing from this principle, that the crank always impels the pendulum in the ſame manner; that is, as it paſſes through the ſemicircle under its centre, always one way; and as it paſſes through the ſemicircle over its centre, always the other way; and it recurs in the ſame ſituation it ſet out from, after theſe two impulſes, which being eaſily made equal by means of the adjuſting ſcrews, notwithſtanding the ſmall difference in length of the levers acted upon, all the ſucceeding impulſes muſt alſo correſpond with theſe, and be equal and regular, as far as regards the eſcapement itſelf. In other eſcapements, if any irregularity exiſts or is worn in any one or more of the teeth or pins in the ſcape-wheel, and the pallets or inclined planes they act againſt, the impulſes given to the pendulum cannot be equal and regular; and the higher the number of the ſcape-wheel, the greater this chance of imperfection.

4thly, Durability and great certainty of continuance. This Eſcapement does not require oil, which, as it becomes clammy and thick by the duſt, is the frequent and well-known cauſe of the ſtopping of others; it does not wear itſelf untrue and out of order. The friction of the collets upon the crank muſt be very ſmall, as the acting ſurface is ſmall, and as the intenſity of the impulſe upon the pendulum is in proportion leſs in this, as it acts upon a longer lever than in others; alſo at the time that the chief force is exerted, as the crank paſſes over and under its centre, there is very little turning of the collets upon it: ſo that I judge this Eſcapement, properly made, ſtands a fair chance of laſting as long as the train itſelf without being out of order; which I underſtand is far from being the caſe with others.

The ingenious part of the Public can no doubt improve upon this application. Of the various methods I have tried, this appears to me the beſt for general uſe. I can ſend the Society drawings* of two other methods which I have tried, if by this they ſhould judge them worthy their notice. In the one, the crank, beſides its own, can be applied with all the advantages of a dead beat, and in the other of a detached eſcapement; but they will not have the advantage of ſilence.

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* The drawings here alluded to, as alſo a model of another Eſcapement, by Mr. Goodrich, are reſerved in the Society's collection.

I do not mean to ſecure this invention to myſelf by a patent: my intention, in preſenting it to the Society, is for the benefit of the Public, hoping at the ſame time, that if the Society find any merit in it, their bounty will be an encouragement to exertion in future, and at preſent ſome recompence for my expence and time; as my family and ſelf, which I have to maintain out of no more than journeyman's wages, do not permit me to undertake any thing of this kind without a proſpect of indemnification.

I can truly affirm this is my own invention; and if, in deſcribing it, I have miſtated any thing, I hope the fault will be attributed to my want of judgement, and not to my intention.

I remain, Sir,

Your moſt obedient ſervant,

Simon Goodrich.

No. 3, Canterbury Walk, Lambeth.
Feb. 12, 1799.

Mr. More.

Fig. 1.

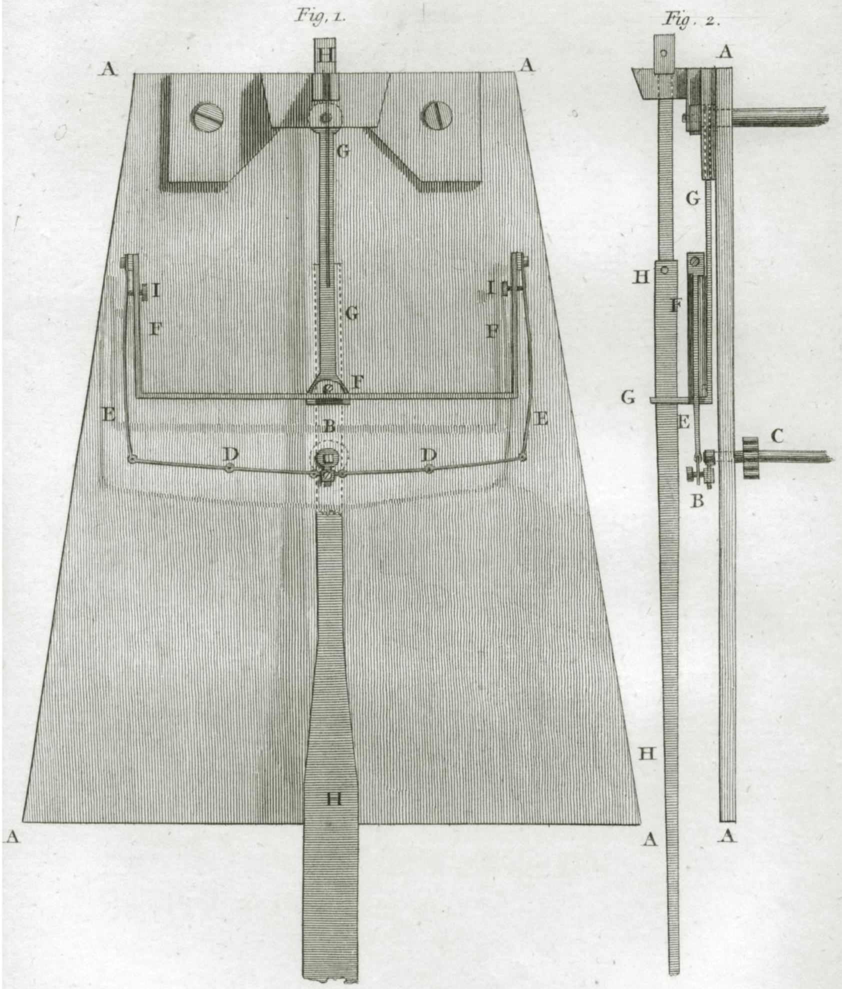


Fig. 1. *Fig. 2.*

Mr. Simon Goodrich's Application of a Crank to answer the purposes of an Escapement in Clocks.

Fig. 1. A front view of the Crank Eſcapement.

Fig. 2. A ſide view of ditto.

The ſame letters of reference are put to the correſponding parts in each figure.

A A A A. The back plate of a Clock.

B. The crank fixed on the end of

C. The arbor of the laſt pinion of the train.

D D. Two ſmall wire chains compoſed of two links only, attached to the crank B by means of two collets, with plenty of liberty upon it. Theſe chains are faſtened to

E E. Two ſmall ſprings ſcrewed to

F F F. A bar that goes acroſs, and is faſtened in the middle to

G G. The crutch, with which

H H. The pendulum is ſuſpended in the common way.

I I. Are two ſcrews going through the bar F, the ends of which being made to act againſt the ſprings E E, ſerve to adjuſt them to a proper diſtance and degree of ſtrength, and by that means eaſily to put the pendulum in proper beat.

In *Fig*. 1. the pendulum is partly repreſented by dotted lines, in order to ſhew the crank, &c.

In conſequence of ſome trials made of a Method of TURNING SPHERICAL FORMS IN WOOD in a more expeditious Manner than uſually practiſed (a Deſcription of which Method is hereunto annexed), the Society this Seſſion voted a Bounty of TWENTY GUINEAS to Mr. THOMAS COOK, of Newington, Surrey; and ſeveral Samples ſo turned by him are reſerved in the Society's Collection, for the inſpection and information of the Public.

SIR,

HEREWITH you receive the method of preparing and turning a true round or ſpherical figure, between two centres, principally upon a large ſcale, by means of the large wheel commonly made uſe of by turners.

Prepare of wood as near a cube as may be; plane one ſide true, and gauge a line down the middle, from which line the centres are at each end found with a pair of compaſſes. Then form the piece to an octagon, by taking off the four corners; place it in the lathe, and lay the band on about one third from the end; then ſtrike each end to the exact length of the intended diameter. With a pair of compaſſes divide the piece which gives the centre or curve line, and biſects the gauge ſtroke; ſtrike it with a chiſſel, then with a ſmall gouge which makes a groove for the band to work in (taking care not to diminiſh the ſize of the diameter); from the middle work down each end with a gouge to as fair a round as you can by eye, or with the callipers: then take the piece out, and carefully prick the ſecond centres, which the gauge ſtroke and curve line give: place in the lathe the laſt pricked centres, and paſs the piece round by hand: work down with a ſmall firming chiſſel, in order to form a ſecond curve line, until it biſects the firſt diameter or curve line: then ſtrike the piece to the firſt centres centers, and work off the remaining wood with a large firming chiſſel, until it becomes fluſh with the ſecond curve line: it may then be poliſhed. Throw off the band, and turn round the ball by hand to work off the groove the band played in. Should you not think fit to paſs the ball by hand, ſhift your reſt to the oppoſite ſide, and have the wheel turn the reverſe way; by this means you turn off the groove. To poliſh the remainder, the band will play on the ſurface of the ball, by being ſteadied with the hand.

I remain reſpectfully,
Your moſt obedient humble ſervant,
THOMAS COOK.

Newington, May 27, 1799.

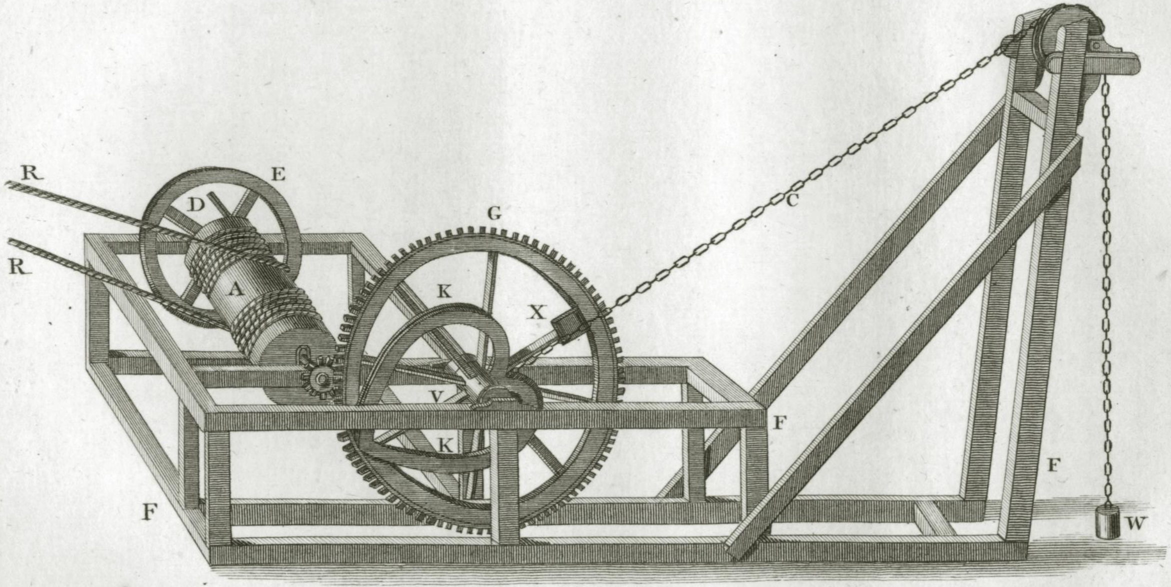
Mr. MORE.

The Thanks of the Society, and the SILVER MEDAL, were this Seſſion voted to Mr. WILLIAM FEATHERSTONHAUGH, for the following Deſcription and Drawing, accompanied with a Model of a Machine invented by him for COUNTERBALANCING THE ROPES uſed in the DEEP SHAFTS OF MINES; which Model is reſerved in the Society's Repoſitory.

SIR,

THE beginning of laſt year I conſtructed a model of a counterbalance, for preſerving a conſtant equilibrium between the ropes uſed in machinery, wrought by ſteam engines or otherwiſe, for the purpoſe of raiſing coals, upon a plan which I had never ſeen or heard before, which I ſhewed to the proprietors of ſome extenſive coal-mines in this neighbourhood, who immediately got a large one conſtructed, which they

Plate 4.



Mr. Featherstonhaugh's Counterballance, for Ropes in deep Mines.

they continue to uſe and prefer to any of the other counterbalances erected in this country. A model of the above counterbalance I now beg leave to ſubmit to the inſpection of the Society, and ſhall be extremely glad if it appears to them of ſufficient utility to merit a deſcription in their tranſactions.

I am, Sɪʀ,

Your moſt obedient ſervant.

Wᴍ. Fᴇᴀᴛʜᴇʀsᴛᴏɴʜᴀᴜɢʜ.

Lambton, near Cheſter-le-ſtreet,
Durham, April 14, 1798.

Mr. Mᴏʀᴇ.

SIR,

YOU will pleaſe to lay before the Society for the Encouragement of Arts, Manufactures, and Commerce, the following account of the advantage which I conceive the counterbalance erected by me to have over thoſe already in uſe; with its dimenſions, &c. The beſt mode that I have ſeen adopted may be thus deſcribed. A chain is faſtened to the axis of the rope-barrel, which, paſſing over a pulley, deſcends into a pit, and is there faſtened to the end of a very heavy chain. When the ropes are in equilibrio, the large chain is at the bottom of the pit; but as the difference of their weights increaſes, the ſmall chain, winding upon the axis of the rope-barrel, lifts up the large one from the bottom of the pit, till it is ſuſpended at full length, at which time one corf has aſcended to the top of the ſhaft. One diſadvantage attending this counterbalance is the depth of the pit for the chain to deſcend into. I meaſured the depth at a machine, upon a colliery belonging to Sir Henry Tempeſt Vane, Bart. and found it to be fourteen fathoms, meaſured from the axis of the pulley to the bottom; the depth of the ſhaft being eighty-eight and a half fathoms.

At Heaton colliery, near Newcaſtle-upon-Tyne, the owners thereof expended near two hundred pounds, in attempting to ſink a pit for the counterbalance chain, but which they could not get ſunk deeper than three and a half fathoms, on account of water; they therefore fixed the pulley five fathoms from the top of the pit, making the whole length of ſpace for the chain to move in, eight and a half fathoms. They have lined the pit near the bottom with metal plates, to prevent the chain wearing away the ſides. I think the chain muſt ſuffer much by friction. The counterbalance which I erected is ſtill uſed at a coal-pit in Harraton colliery, ſituated about two miles from Cheſter-le-ſtreet, and belonging to the truſtees of the late William Henry Lambton, Eſq. The depth of the pit for the counterbalance is five fathoms, meaſured from the axis of the pulley to the bottom. The weight ſuſpended at the end of the chain is thirty one and a half hundred weight; diameter of the wheel, fifteen and a half feet; depth of the ſhaft, ſeventy-ſix and a half fathoms; and weight of ſeventy-ſix and a half fathoms of rope, five hundred weight two quarters. Another diſadvantage attending the counterbalance firſt deſcribed is, that it does not regularly take off the weight of the heavier rope, which will appear by conſidering that, immediately after the corves have paſſed each other in the ſhaft, and the difference of the weights of the ropes very ſmall, the leſſer chain is acting very powerfully upon the axis, which is of an equal diameter in each part whereon the chain winds. According to my plan, there is an irregularity occaſioned by the weight of the chain, but it is very trifling. One inconvenience which may poſſibly attend the counterbalance I invented is, that as the engine-men, through inattention, ſometimes draw a corf over the pulley above the ſhaft, the weight at the end of the chain may be drawn too high, and ſome part of the machinery broken; but during a year and a quarter's conſtant uſe of this counterbalance, the engine-man, though he has ſometimes drawn a corf over the pulley, has always been able to ſtop the machine before any accident happened. It would conſiderably diminiſh the friction, to fix the large wheel nearly in a horizontal poſition, with bevel teeth, ſo that its weight might reſt almoſt entirely on one end of the axis. The counterbalance formerly uſed at Harraton colliery is on the following conſtruction. A large wheel, with a weight fixed therein, near to its circumference, is placed directly above a pinion on the end of the rope barrel: when the ropes in the ſhaft balance each other, the weight is at reſt; but the machine being put in motion, the pinion turns the large wheel, and the weight aſcends till it has deſcribed a quadrant of a circle, at which time its power is the greateſt, and one rope has reached the top of the ſhaft. This counterbalance does not act uniformly, and its power is very ſmall. There has been a counterbalance erected at Heaton colliery, about fourteen or fifteen weeks ago, by Mr. Jeffreys, an engineer, near Newcaſtle-upon-Tyne, on nearly the ſame conſtruction as mine; the principal difference being, that in his the chain hangs directly from the wheel, and the weight moves in a gutter. Mr. Jeffreys ſays, he never had an opportunity of bringing it into uſe before; but was ſhewn a model of it above ſix years ago, by a perſon of the name of Crowther, who I ſuppoſe is employed under him. When I recommended the new counterbalance to be erected at Harraton, the proprietors were uſing the old one deſcribed above, having the large wheel directly over the pinion. They made the improvement without taking down the large wheel; and on account of its being in rather a bad ſtate, they have not much more than one ton weight ſuſpended at the end of the chain.

I am, Sir,

Your moſt obedient ſervant,

Wm. Featherstonhaugh.

Lambton, near Cheſter-le-ſtreet,
November 30th, 1798.

Mr. More.

WE the underſigned, being the managers of Lambton, Harraton, Bourn Moor, Lumley, Murton and Penſhaw collieries, and two of the proprietors of the machinery erected thereon for the purpoſe of drawing coals, do certify that we have uſed about fifteen months a counterbalance recommended by Mr. William Featherſtonhaugh. It is the beſt method that has ever been propoſed to us, and we believe it to be his own invention.

T. CROUDACE.
M. FEATHERSTONHAUGH.

THIS is to certify that I conſtructed a counterbalance laſt year for Meſſrs. Featherſtonhaugh, Fenwick, and Croudace, according to a model ſhewn me by Mr. Wm. Featherſtonhaugh. I have endeavoured to compare the expence of a counterbalance on his plan with that of a counterbalance by means of a large chain for the depth of ſeventy-ſix and a half fathoms, and am of opinion that there will be little difference in the firſt coſt. In caſe there is much water, the latter method will be a great deal more expenſive. I think his counterbalance may be upholden and replaced at new pits, for leſs expence. I believe the invention to be new, as I never heard of it before.

JACOB WEATHERBURN.
Engine-wright.

A Deſcription of the Plate repreſenting the Counterbalance invented by Mr. WM. FEATHERSTONHAUGH.

F F F Are the different parts of the framing. A ſteam-engine is ſuppoſed to turn the barrel A by means of a crank at the end D. E is a fly wheel. R R are the ropes which deſcend into the mine. When the engine is put in motion, the barrel A revolves, and, by means of a pinion on the end of its axis, turns the wheel G; the chain C, with a weight W at the end, winding upon one of the curves K K, which are formed of pieces of timber ſtrongly faſtened to the arms of the wheel G, and in which grooves are cut to prevent the chain from ſlipping off. The teeth of the wheel and pinion are of caſt iron. A pit muſt be dug for the weight W to deſcend into, but it need only be of a very ſmall depth; whereas, in the beſt counterbalances which I have ſeen, a pit of conſiderable depth is neceſſary, in the ſinking of which, in ſome inſtances, when there has been much water, I have known a very large ſum expended. When the wheel G has revolved ſo far that the chain makes a right angle with the arm V, at the extremity thereof; it then acts with its greateſt power, and the difference of the weights of the ropes is the greateſt. The curves K K were attempted to be drawn of ſuch a form, that as the wheel G revolved, a perpendicular let fall from its centre upon the line of direction of the chain might uniformly increaſe; but according to the method in which I have applied the chain, it could not be done perfectly exact. X is a weight to balance the curved pieces of timber on the oppoſite ſide of the wheel. Where there are ſeveral ſtrata of coal in one pit, if a counterbalance be calculated for the deepeſt, it will anſwer for the reſt without alteration. Where the depth is very great, two counterbalances may eaſily be applied; or the power of this counterbalance may be encreaſed by making the ſpiral-ſhaped pieces of timber extend beyond the circumference of the wheel.

The Thanks of the Society were this Seſſion voted to Sir THOMAS HANMER, Bart. for the following Account and Drawing of a Method of LAYING ON WATER UPON WATER-WHEELS, as practiſed by him in Flintſhire.

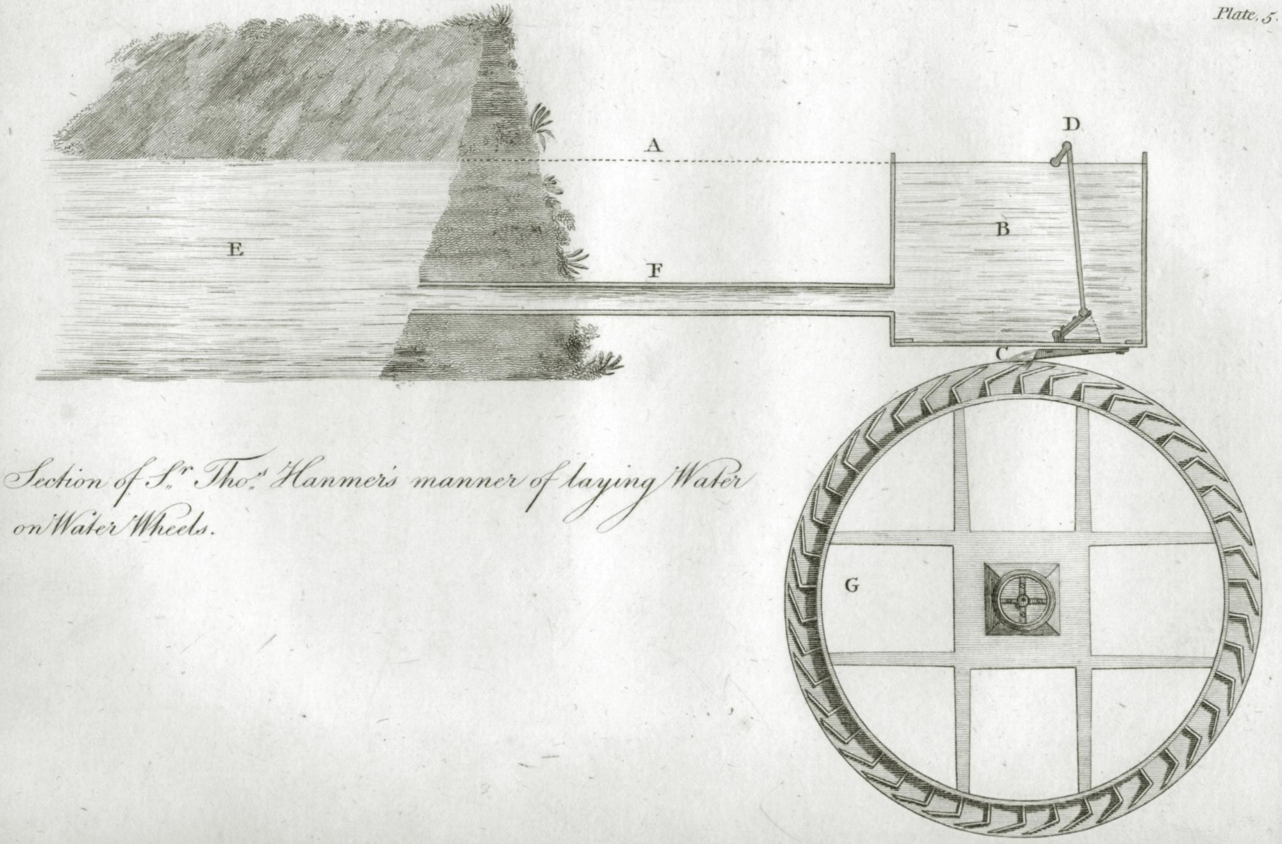
SIR,

THE old method of conveying water from a higher level to an overſhot mill wheel, proving ſo deſtructive to the different timbers and working gear of all mills of this deſcription, by the ſplaſhing and beating of the water overflowing the buckets, its extreme waſte of water, and the retrogade manner in which the water is diſcharged from the bucket cauſing rather a ſtagnation in the water under the wheel, where the fall is not very great; and floods are very apt to dam or tail-back, and thereby impede or clog the regular motion of the wheel; have induced the proprietor to try the following plan hereunto annexed, and which has been adopted at an overſhot corn-mill in Flintſhire, with the aſſiſtance of Mr. John Wilkinſon, Iron-maſter, of Birſham Forge, Denbighſhire.

A. The line of high-water level.
B. The iron ciſtern.
C. The valve to the ciſtern.
D. The lever that lets the water on the wheel.
E. The pool dam.
F. The iron pipe, through which the water is conveyed from the pool to the ciſtern.
G. The large wheel.

By the delivering the water from a valve in the ciſtern, which is of caſt iron, a little beyond the centre of the wheel, you are able to obtain the motion of an underſhot wheel without the loſs of any water or injury to the mill-work by perpetual ſplaſhing, as by the old method. There is a great ſaving of water by this plan, ſo as to enable the mill to do nearly double the

Plate. 5.



Section of S^{r}. Tho^{s}. Hanmer's manner of laying Water on Water Wheels.

work with the ſame ſupply of water, compared with what it did in the old way. The motion is quicker, and the wheel rids itſelf with greater eaſe, and the water paſſes off with great rapidity, and acts with greater power againſt floods and froſts: the whole of the wheel and ciſtern ſhould be covered from the weather: the bore of your pipe may be of any dimenſions, according to your ſupply of water. It was completed at Hanmer in 1797; and from its ſucceſs, the proprietor is induced to give a plan and ſection to the Public, and to lay it before the Society for the Encouragement of Arts, Manufactures, and Commerce, for their information; not doubting, from the ſucceſs he has experienced, that if more frequently adopted, it may admit of conſiderable improvement, and be of great utility.

I am, SIR,
Your obedient ſervant,
THOMAS HANMER, Bart.

Bettisfield Park, May 27, 1798.

Mr. MORE.